РОЗДІЛ 3

МАТЕМАТИЧНЕ МОДЕЛЮВАННЯ ТА ОПТИМІЗАЦІЯ СИСТЕМ ОБРОБКИ ІНФОРМАЦІЇ ДЛЯ ВИРІШЕННЯ ЗАВДАНЬ ОСВІТИ, НАУКИ І УПРАВЛІННЯ ВИРОБНИЦТВОМ

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DEVELOPMENT AND RESEARCH OF A TRAFFIC CONTROL SYSTEM AT THE INTERSECTION

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Introduction. This paper is about development and research of traffic management system at intersections. Every year, the number of cars on the roads is increasing, and therefore issues such as optimizing or adjusting traffic lights are still relevant and until a solution is found that can overcome all the problems.

The main objective is to try to reduce the downtime of cars at traffic lights by improving the traffic lights and turning it into a standalone system that can evaluate the situation on the road, and recalculate the allotted time for all directions it manages.

A lot of the problem in this matter lies at the intersections. As it is the main place where two or more traffic flows need to be synchronized.

The aim of this paper is development smart traffic control system at the intersection with function evaluate the situation on the road.

Ready-made solutions. This problem is already being considered by many leading countries in the world, and Japan in this task has taken steps to solve this problem:

1. A road section with a fully automated traffic light or a group of traffic lights connected to each other that are monitored using special sensors for traffic on the road and reconfigures the time allocated to the streams in real time.
2. A section of the road that is under the control of a special group of people - who monitor traffic, and manually reconfigures traffic lights.

Traffic lights are configuring in Ukraine according to the principle of statistical calculation of the flow on a section of road at different times of the day, and on the basis of these data the time allocated for a particular flow for that section is calculated. The duration of the regulatory cycle is calculated using the Webster formula [1]:

$$T_c = \frac{1.5\times\sum_{i=0}^{n} T_i+5}{1-\sum_{i=0}^{n} y_i}. \qquad 1)$$

where T_c - duration of the regulatory cycle, s;
T_i – lost time at intermediate tact (yellow traffic light signal) on *i* cycle, s;
y_i – phase coefficient, the largest value is determined by the formula [2]:

$$y = \frac{N}{M_H}. \qquad (2)$$

where N – traffic intensity in one of the directions regulated by the traffic light, car/hour;

M_H – saturation flow, car/hour.

The main problem with this method is that the measurements are made only a few times and adjust the traffic light statically based on these measurements [3].

Solve. Instead, it is suggested to modify the entire system so that it can predict flows based on sensor data and reconfigure itself.

To ensure that the necessary flow of traffic values for traffic lights are obtained, we will use on the term "sensor". Schematically, a map of sensors and links with traffic lights for two intersections is presented in figure 1.

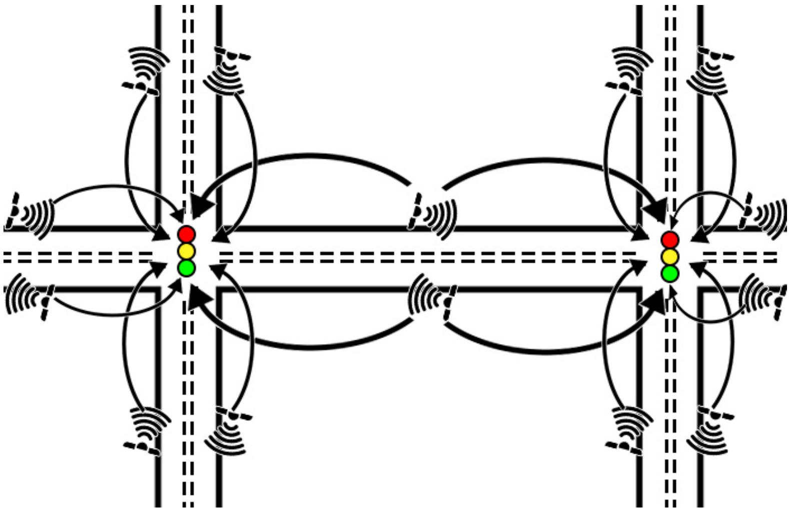

Fig. 1. Map of sensors and links with traffic lights for two intersections

Since the development of sensors for this system is not the topic of this report, we abstract from this issue. The sensors will be placed in such a way that each traffic light in the system has a complete picture of the situation at the road for which it is responsible.

On the basis of the data obtained stand out more time for travel for a flow of traffic with a higher density is allocated. Traffic lights that are connected in one system in the form of a double-link graph reconfigure a route with a large stream to the road with a green wave.

1. Modification the formula (2) that way that it calculated flow in minute and not in hour:

$$y' = N_{min} \frac{60 \frac{R_k + R_{k-1}}{2}}{M_H}. \qquad (3)$$

where N_{min} - traffic intensity on one of the counters regulated by the light data received from the sensors in the last minute, car/minute;

R_k – flow prediction coefficient relative to traffic flow.

2. Modification the formula (1) that way that it calculation regulatory cycle at the crossroad by average between previous and current flow of traffic values:

$$T'_c = \frac{1.5 \times \sum_{i=0}^{n} T_i + 5}{1 - \frac{\left(\left(\sum_{i=0}^{n} (y')_i\right)_{j-1} + \left(\sum_{i=0}^{n} (y')_i\right)_j\right)}{2}}. \qquad 4)$$

where $(\sum_{i=0}^{n}(y')_i\ )_j$ – sum of phase coefficient that have been calculate now;
$(\sum_{i=0}^{n}(y')_i\ )_{j-1}$ – sum of phase coefficient that had calculated previous.

3. And modification last formula for green signal traffic light:

$$T_g = \frac{\left(T'_c - \sum_{i=0}^{n} T_i\right) \times y'_i}{\frac{\left(\left(\sum_{i=0}^{n} (y')_i\right)_{j-1} + \left(\sum_{i=0}^{n} (y')_i\right)_j\right)}{2}}. \qquad 5)$$

Next, you need to check the conditions for allocating sufficient time for pedestrians to pass the road [1]. This is provided in the rules for setting up regulated intersections. This is done according to the formula:

$$T_p = \frac{l_r}{V_p} + 5. \qquad 6)$$

where T_p – time for pedestrians to pass the road;
l_r – the width of the road;
V_p – average speed of pedestrians.

Conclusions. When applying this method, we get a decrease in queues at intersections. In different situations, this numeric is different, but the increase in efficiency reaches 10%.

The main advantage this approach is that in the morning and evening peak of traffic the number of cars is the same, but their direction is opposite, this approach allows you to very effectively solve this situation. And also this method will solve temporary problems that are not typical for a given time of day on the roads, such as an accident that will change the flow characteristics.

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ANALYSIS OF SIR MODEL FOR PREDICTING THE SPREAD OF MEASLES

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Introduction. The main task of the health care system in any country is to control the spread of infectious diseases. The social consequences, as well as the material losses, strongly demonstrate the need to predict the occurrence of epidemics. Measles is one of the most contagious diseases. In Ukraine, according to the Public Health Center of the Ministry of Health of Ukraine, more than 115,000 people have contracted measles since summer 2017, 41 of whom have died [1]. Simulation of the measles spreading allows to predict new outbreaks of measles and evaluate the strategy to prevent them.

The aim of this paper is to analyze the SIR epidemic model for simulation of the spread of infectious diseases and to select the appropriate model extension for modeling the spread of measles.

Epidemiology of measles. Measles is a viral infectious disease that starts in the respiratory system. Symptoms of measles generally first appear within 10 to 12 days of exposure to the virus. They include cough, fever, runny nose, red eyes, sore throat white spots inside the mouth. A widespread skin rash is a classic sign of measles. This rash lasts up to 7 days.

Measles can be spread through the air. An infected person release the virus into the air through coughing or sneezing. A susceptible person that is exposed to the measles virus has a 90 percent chance of becoming infected. An infected person is contagious for 4 days before the characteristic rash appears and for another four days after the rash.

Getting vaccinated is the best way to prevent measles. Two doses of the vaccine are approximately 97% effective at preventing measles, while one dose is about 93% effective. When rates of vaccination within a population are greater than 92% outbreaks of measles typically no longer occur. During 2000 – 2017, measles vaccination prevented an estimated 21.1 million deaths throughout the world [2].

The classical SIR model. A significant contribution to the mathematical modeling of epidemics has been made by W. O. Kermack and A. G. McKendrick in their scientific work “A Contribution to the Mathematical Theory of Epidemics” [3], published in 1927. The SIR model, which was described in their scientific work, is now one the most popular models for modeling the spread of infectious diseases. The authors divided the whole population into three groups: